MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2016/2017

EPM4086 – DIGITAL CONTROL SYSTEMS

(RE)

11 OCTOBER 2016
9.00 a.m. - 11.00 a.m.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 5 pages including cover page with 4 Questions only.
2. Attempt **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.
3. Please write all your answers in the Answer Booklet provided.
4. Table of Transform pairs has been included in Appendix.

Question 1

(a) Determine the z-transform of the following functions using partial fraction method. Use the table of z-transform pairs given in appendix as a reference.

(i) $F(s) = \dfrac{10}{s^3 + 6s}$

[6 marks]

(ii) $F(s) = \dfrac{20}{s^2(s+6)}$

[9 marks]

(b) A signal $f(t) = e^{-3t}\sin 3t$, $t \geq 0$ is sampled by an ideal sampler with sampling period T. Determine the sampler output $f^*(t)$ and evaluate its pulse transform $F^*(s)$.

[10 marks]

Question 2

(a) For the closed loop sampled data control system shown in Figure Q2 (a), determine the output $C(z)$ in z-domain.

[12 marks]

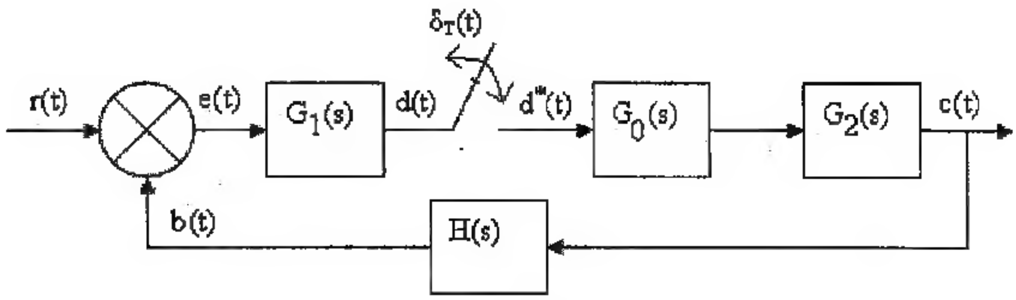

Figure Q2 (a)

(b) The input-output relation of a sampled data system is described by the equation

$$c(k+2) + 3c(k+1) + 2c(k) = u(k)$$

Determine the output response $c(k)$ of the system with initial conditions $c(0) = 1$ and $c(1) = -3$.

[13 marks]

Continued...

Question 3

(a) The Characteristic equation of a discrete control system is given as

$$F(z) = z^3 - 0.2z^2 - 0.25z + 0.05 = 0$$

Using Routh-Hurwitz stability test, determine

(i) The stability of the system

[11 marks]

(ii) The number of z-plane poles of the system lying inside, outside and on the unit circle.

[2 marks]

(b) The open-loop transfer function of a unity feedback control system is given as

$$G(z) = \frac{0.3679K(z + 0.7181)}{(z-1).(z-0.3679)}$$

Determine

(i) The starting and terminating points of the branches

[3 marks]

(ii) The breakaway / breakin points, if any,

[6 marks]

(iii) The gain K at the breakaway point.

[3 marks]

Continued...

Question 4

(a) For the discrete time system modeled by the following dynamic equations (state vector is $x(k)$, input is $u(k)$ and output is $c(k)$).

$$x(k+1) = Ax(k) + Bu(k); \quad c(k) = Dx(k)$$

$$A = \begin{bmatrix} -1 & 1 \\ -0.5 & 0.2 \end{bmatrix}; \quad B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}; \quad D = \begin{bmatrix} 1 & 0 \end{bmatrix}$$

Obtain the transfer function $\dfrac{C(z)}{U(z)}$

[10 marks]

(b) Given the state equation $x(k+1) = Ax(k)$, find the state transition matrix $\phi(k)$ if the A matrix is given by

$$A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}$$

[12 marks]

(c) Draw the state diagram of the discrete time system described by the state model,

$$\begin{bmatrix} x_1(k+1) \\ x_2(k+1) \end{bmatrix} = \begin{bmatrix} 6 & 0 \\ 0 & 3 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix} + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u(k) \text{ and } y(k) = \begin{bmatrix} 4 & 8 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix} + 20u(k)$$

[3 marks]

Continued...

Appendix

TABLE OF Z-TRANSFORM PAIRS

(e = Euler number)

Time function $f(t); t > 0$	**Laplace Transform** $F(s)$	**Z-transform** $F(z), T =$ **Sampling time**
$u_s(t)$	$1/s$	$z/(z-1)$
t	$1/s^2$	$T z/(z-1)^2$
t^2	$2/s^3$	$T^2 z(z+1)/(z-1)^3$
ε^{-at}	$1/(s+a)$	$z/(z-\varepsilon^{-aT})$
$1-\varepsilon^{-at}$	$a/\{s(s+a)\}$	$z(1-\varepsilon^{-aT})/\{(z-1)(z-\varepsilon^{-aT})\}$
$t\varepsilon^{-at}$	$1/(s+a)^2$	$Tz\varepsilon^{-aT}/(z-\varepsilon^{-aT})^2$
$\sin at$	$a/(s^2+a^2)$	$z\sin aT/(z^2-2z\cos aT+1)$
$\cos at$	$s/(s^2+a^2)$	$z(z-\cos aT)/(z^2-2z\cos aT+1)$
$\varepsilon^{-at}\sin bt$	$b/\{(s+a)^2+b^2\}$	$z\varepsilon^{-aT}\sin bT/(z^2-2z\varepsilon^{-aT}\cos bT+\varepsilon^{-2aT})$
$\varepsilon^{-at}\cos bt$	$(s+a)/\{(s+a)^2+b^2\}$	$(z^2-z\varepsilon^{-aT}\cos bT)/(z^2-2z\varepsilon^{-aT}\cos bT+\varepsilon^{-2aT})$

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